New Horizons Kuiper Belt Object Search Update

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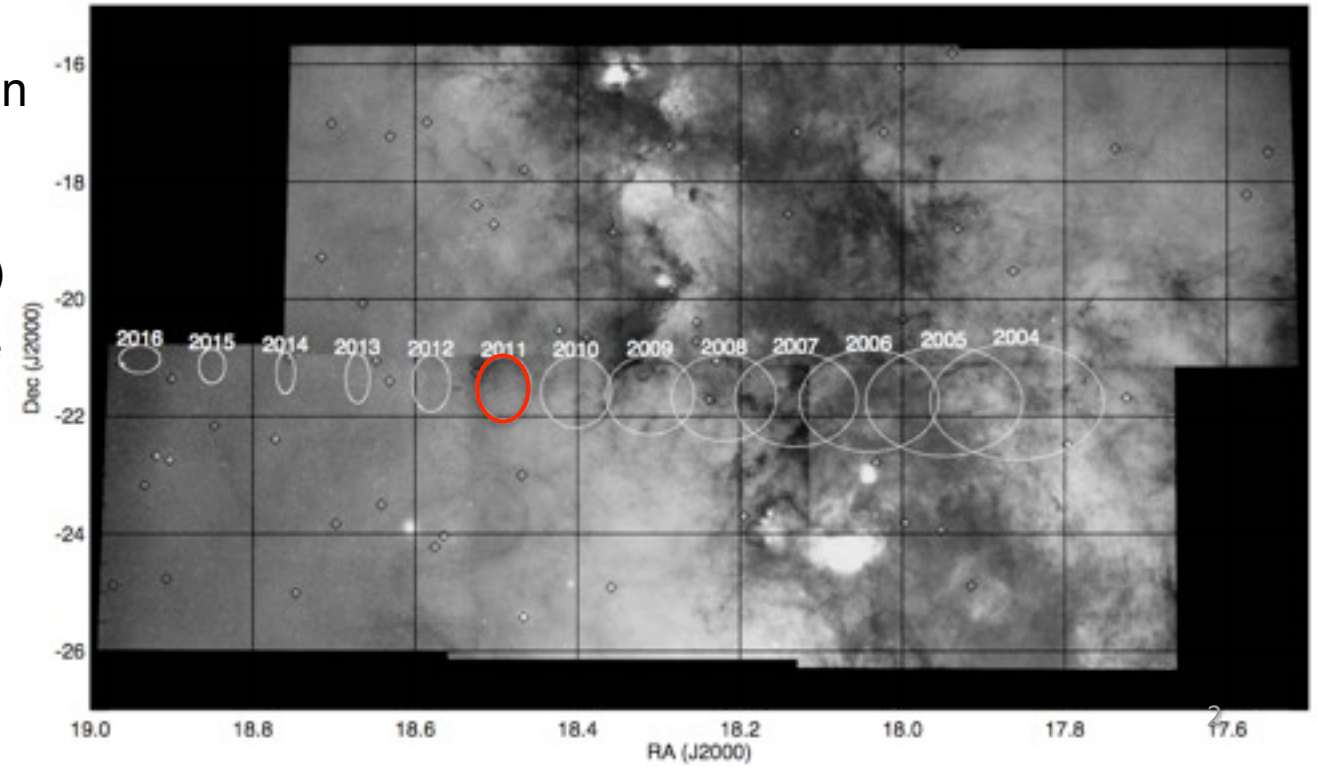
and the KBO Search Team

New Horizons Science Team Meeting
Ames Research Center
January 19th 2011

This is the Year

- 2011 is the year to begin the full search for KBO flyby targets
  - Search area is now small enough to be searched to sufficient depth
  - 4 observing seasons remain until the flyby target must be chosen, sufficient time for
    - Orbit determination
    - Physical characterization
    - Weather insurance (within reason)
  - However, we are still in dense Milky Way star clouds



Number of accessible KBOs

- Need to reach R Mag. 26.0 – 26.5 for some confidence of success
- R Mag 25.0 (~70 km diameter) target is plausible
- CFHT limit R=26 ?
- Subaru limit R=26.5 ?

R Mag	Diameter, p=0.1, R=42 AU	Expected# KBOs, 160 m/sec δv		
		Spencer. DPS 09	Kavelaars, Spring 2010	Kavelaars, scaled
24.0	115	0.1		0.3
24.5	91	0.2		0.5
25.0	73	0.5		1.3
25.5	58	1.0	2.5	2.5
26.0	46	2.1		5.3
26.5	36	4.0		10.0
27.0	29	7.0		17.5

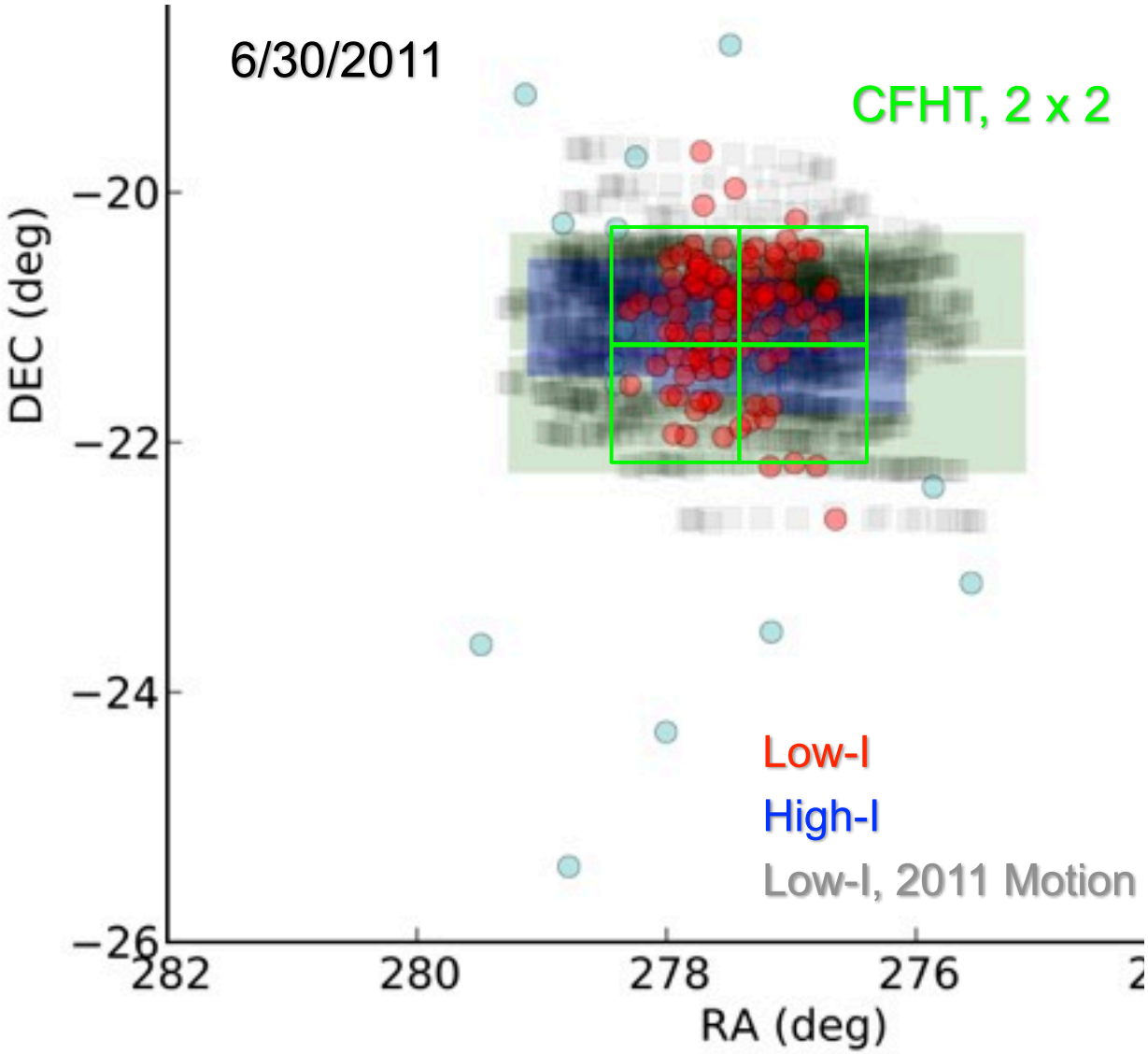
Chosen Tools

- Subaru/SuprimeCam
  - 8-m aperture
  - 0.20 deg^2 field of view
- Magellan/MegaCam
  - 6.5-m aperture
  - 0.17 deg^2 field of view
- CFHT/MegaPrime
  - 3.6-m aperture
  - 0.90 deg^2 field of view

Proposals for all facilities submitted and accepted, Fall 2010

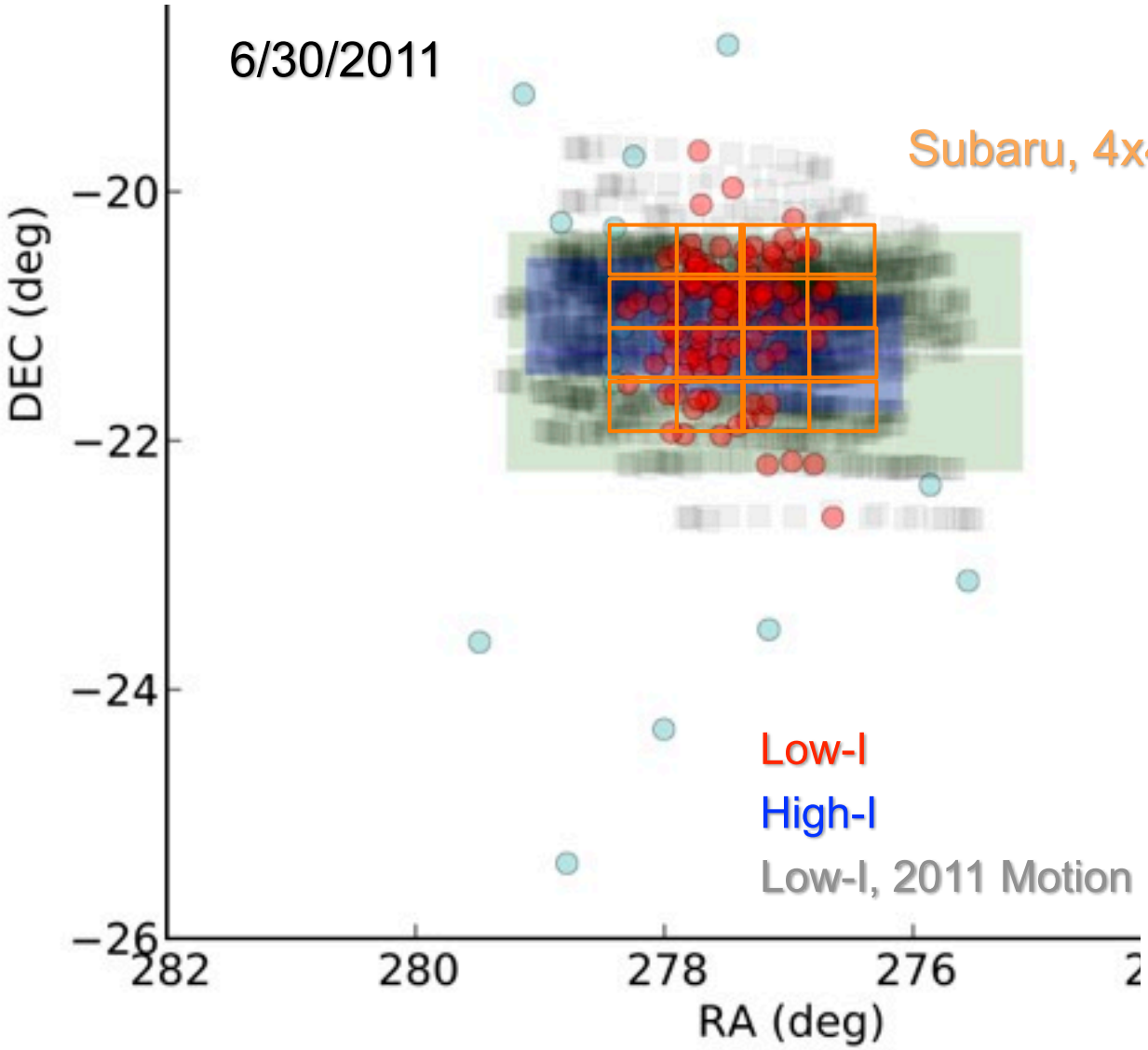
- Additional possibilities in 2012?

Search Area



- Search area from Kavelaars, based on CFEPS Kuiper Belt model
- Confirmed by Spencer, Buie, and Wasserman

Search Area, Subaru

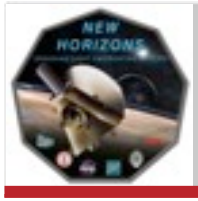


- Magellan similar

Proposal Status

- Dark time April/May, May/June, and June/July

Telescope	TAC	Camera	PI	Nights Request-ed	Dates Request-ed	Nights Granted	Dates granted (local date at start of night)	Comments
Subaru	Subaru	SuprimeCam	Sheppard	2	Jun/Jul	0		
Subaru	Keck	SuprimeCam	Spencer	4	Jun/Jul	2	July 1, 2	
Subaru	Hawaii	SuprimeCam	Tholen	3	May/Jun	3	May 28, 29, 30	
Subaru	Gemini	SuprimeCam	Trilling	3	May/Jun	1	May 31	
CFHT	Canada	MegaPrime	Kavelaars	9 hrs	Jun/Jul	Yes	Queue	
CFHT	France	MegaPrime	Petit	18 hrs	Jun/Jul	Yes	Queue	Priority 2, but "shouldn't be a problem in July"
Magellan	Arizona	MegaCam	Fuentes	2 x 0.5	Apr/May	2 x 0.5	May 29, 30	
Magellan	CfA	MegaCam	Holman	2 x 0.5	Apr/May	2	June 3, 4	May be able to swap early parts of the night for May 2-5 time
Magellan	MIT	MegaCam	Binzel/Gulbis	2 x 0.5	Apr/May	2 x 0.5	May 25-28	Exact dates in this period TBD
Magellan	Carnegie	MegaCam	Osip	4 x 0.5	Apr/May	4 x 0.5	Apr 26, 27, 28, 29	Moonlight shortens first two nights
Magellan		IMACS	Osip	2	Jun/Jul	2	June 30, July 1	Sheppard also has July 2nd for his own work
CFHT	Hawaii	MegaPrime	Tholen	0.5 hr	Apr/May	0.5 hr	Queue	Astrometry proposal



Proposal Status Summary

- We have all the requested CFHT, Magellan time, half the requested Subaru time
- Time spread will provide 2-month arcs for preliminary orbits
- CFHT Astrometric grid will be obtained early to facilitate image registration and orbit determination

Telescope	Camera	Dark Time	Total Nights Requested	Total Nights Granted	Comments
Subaru	SuprimeCam	Jun/Jul	6	2	
Subaru	SuprimeCam	May/Jun	6	4	
Magellan	MegaCam	Apr/May	5	2	
Magellan	MegaCam	May/Jun	0	3	Some swappable for Apr/May time?
Magellan	IMACS	Jun/Jul	2	2	IMACS is less efficient than SuprimeCam or MegaCam
CFHT	MegaPrime	Jun/Jul	3.3	3.3	Queue scheduled: assume 8 hours = 1 night. Some is priority 2 but "shouldn't be a problem in July"
CFHT	MegaPrime	Apr/May	0.1	0.1	Shallow imaging for astrometric grid
		Total	**22.4**	**16.4**	

Recent Planning Progress

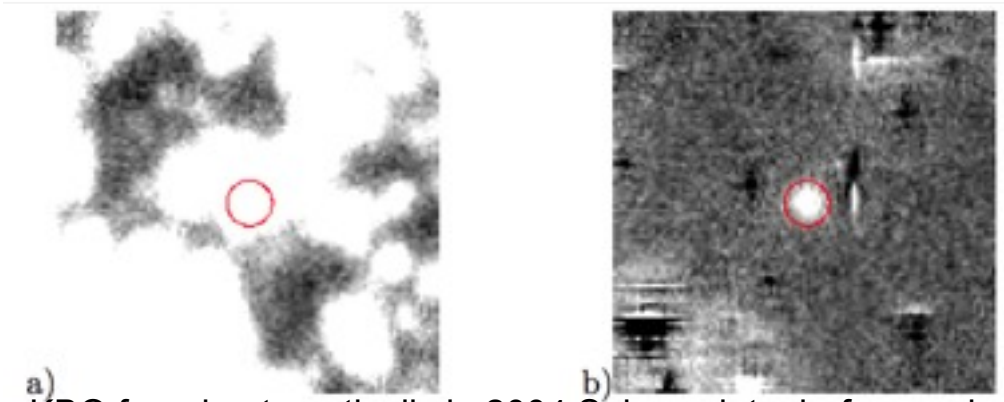
- Call for data reduction funding proposals issued, two proposals selected
- CFHT astrometric observation (queue-scheduled) plan is complete (Buie, Kavelaars, Tholen)
- Beginning monthly (or more frequent) telecons in ~2 weeks (Spencer)
- Setting up Wiki / Forum for discussion and information sharing (Steffl?)

To Do Next

- Formulate unified observation strategy
  - Optimize search area vs. search depth vs. cadence
  - Exposure times, dither/tracking strategies
  - Contingency plans for weather losses
- Observing logisitics
  - Who goes to which telescopes, when?
    - Travel expenses to be covered by the project- details TBD
  - How to distribute the data?
- Refine data reduction tools using existing search data
  - Be ready to turn the crank on the new data from all telescopes, starting in late April
    - Need to demonstrate ability to find targets before Sept. 2011 proposal deadline for 2012 observations
  - Pay particular attention to lessons learned that will affect the 2011 observing strategy
- Determine strategy and write proposals for Aug., Sept. 2011 follow-up observations
  - E.g., NASA Keck proposals (Subaru) due March 17th

Data Reduction Tools

- Project is funding parallel data reduction programs by Buie, Holman
  - Kavelaars, Fabbro developing tools for CFHT with own funding
- Very crowded fields: subtraction of static background stars is essential to find targets
  - Need to register geometry, match PSF, transparency
- Moving objects must then be found and linked between visits
  - Subtraction artifacts complicate automated detection
- Buie has developed tools based on 2004/2005 Subaru data
  - Efficiency is unknown but needs improvement.
- Eyeballs may be better than algorithms at finding real objects amid subtraction artifacts
  - Crowdsourcing…?
- Success is not guaranteed!



KBO found automatically in 2004 Subaru data, before and after background subtraction (Buie)

Welcome to the ZOONIVERSE

Origins

Born out of Galaxy Zoo

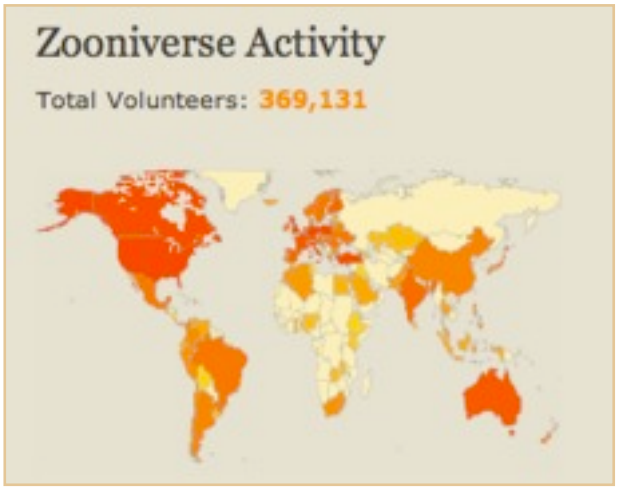
- Launched July 2007
- Classified nearly 1 million SDSS galaxies!
- Spawned 2 new editions: Galaxy Zoo 2 & Galaxy Zoo: Hubble
- Produced data used in over 2 dozen journal articles, primarily in MNRAS
- Major Discoveries: *Hanny's Voorwerp*, *the Green Peas*, *blue elliptical* & *red spiral galaxies*, and catalogues of *morphologies*, *major mergers*, and *overlapping galaxies (in progress)*

Welcome to the ZOONIVERSE

Organization

Administered by the CITIZEN SCIENCE ALLIANCE

- A pay-to-join collaboration that includes: Adler Planetarium, Johns Hopkins University, University of Minnesota, The University of Nottingham, University of Oxford and Royal Observatory Greenwich.
- Many other institutions have individuals working as official collaborators on individual projects with early access to data prior to publication of catalogues.
- Maintains servers, central login services, and distributes all communications to users
- N.B.: *All grants involving Zoos must be cleared through CSA prior to submission, and some overheads may be requested*



as of 2011 Jan 6

Welcome to the ZOONIVERSE
Moon Zoo Tasks

Image Annotating

- Outline Craters
- Indicate Boulderiness *(None, Some, Many)*
- Mark Spacecraft Debris
- Mark Crater Features *(Bench / Mound / Flat, Dark haloed, Fresh white, elongate pits)*
- Mark Linear Features *(Boulder tracks, Crater chain, Sinuous channels, Other linear feature)*

Welcome to the ZOONIVERSE
KBO Zoo

What's Needed! Science Leadership

- A list of science questions people want to answer with the data (and will work on)

What can be done beyond finding KBOs?

- Specifications on what data is needed to answer those questions (and feedback on design)
- A commitment to take produced data to published research *where relevant*

What's Needed! Public Communications

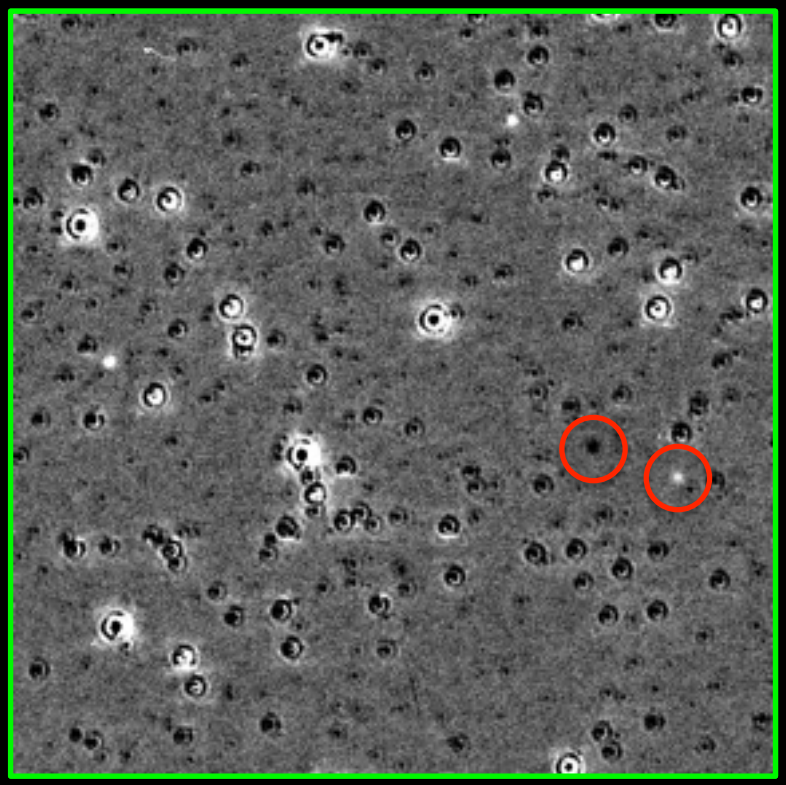
- A commitment to discuss progress & achievements on the project blog
- Be a source of answers when forum moderators need help
- Include, where relevant, citizen scientists in doing published research

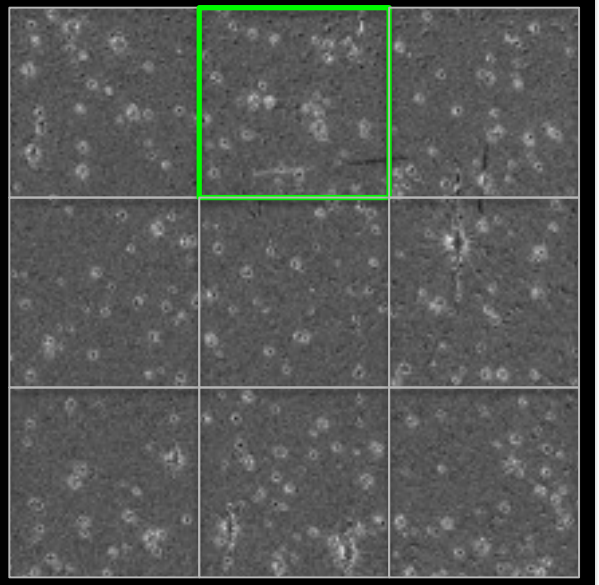
Immediate Next Steps

- Setup a project related workspace
- Brainstorm questions and define who leads which science topics

Strawman KBO Zoo Interface?

Expected KBO motion,
this frame pair





Subaru SuprimeCam
July 1st 2011, Field 11, Detector 5,
Visits 2 and 3
Section 2

Click on both images of potential KBOs